5 COMMUNICATIONS INVENTORY AND PLANNING

5.1 Introduction

Chapter 5 is focused on two aspects of Illinois ITS communications: a partial inventory of current communications systems and a vision of a statewide communications network that would support ITS requirements between districts and across the state.

- To establish fundamental design criteria, the communications requirements for ITS are reviewed and requirements established.
- From these requirements, high-level models of the communications networks are developed, based on the anticipated uses of the network.
- After identifying the existing communications capabilities within the State and IDOT districts, a concept is presented that will overlays the envisioned network on today's capabilities and identifies missing areas.

5.2 Requirements for the Statewide Communications Network

5.2.1 A. Operational Objectives of the Statewide Communications Network

The Statewide Communications Network is a wide area, telecommunications network used to transfer video and information across Illinois. The primary focus is linking IDOT operations centers using the Center-to-Center protocols of the National Transportation Communications for ITS Protocols (NTCIP). It is envisioned that this network will extend the local area networks and metropolitan area networks of the IDOT districts and regions to provide a network that covers all of Illinois.

INFORMATION TRANSFER

The primary use of the statewide communications system is the transport of information. Using a hierarchical organization of information transfer, with the data exchange between field equipment and the local traffic management center as the lowest tier, it is envisioned that the statewide communications level support ITS requirements at the higher tiers of the hierarchy, with center-to-center communications dominating.

- Center-to-center – One application of the statewide communications network will be to provide information transfer between centers of operation. While this could include centers within a region, it is envisioned that the focus will be on transferring information from regional centers to Springfield or between inter-regional centers such as District 2 to District 1. This would also include operational centers of different agencies, such as Chicago's Office of Emergency Management and Communications (OEMC) exchanging data with the State Emergency Operations Center (SEOC) in Springfield.
- Inter-district Command and Control – There may be institutional desires to allow one district (may also be referred to as a region) to assume control of another's field equipment or to share the resources of an operations center during times of crisis or during non-peak hours of operation. Thus, an operations center in one district could provide 24/7 operation for multiple districts during the non-peak hours. It would also

allow centralized control for special operations such as issuing Amber alerts. It should be noted, however, that merely providing the capability to communicate between centers does not necessarily provide the capability to interoperate. Interoperation is a function of the system software. This requirement must be addressed during the system design and implementation.

- Inter-state – The statewide communications network can also be used to exchange information between Illinois and a neighboring states' departments of transportation. The current focus is to provide this exchange through the Illinois and GCM gateways and their existing communications. While the existing systems could continue to provide these functions, ultimately it might be desirable to use the statewide network, especially for states not currently connected to the GCM Gateway such as Missouri and Iowa.

Potential Users

It is anticipated that the primary users of the statewide communications system will be the nine districts of the Illinois Department of Transportation (IDOT), the Central Office, and the Illinois Gateway.

The network will be used by these agencies to share near real-time traffic information. A second use will be to share operations between regional centers. Using the statewide network, it should be possible to operate one region's field elements remotely from another region or district. This would allow shared operations and reduce overall personnel requirements.

The IDOT districts are located throughout Illinois, as identified in Table 5.1. It is envisioned that each of these districts will be ultimately connected to the Statewide ITS Communications Network.

Table 5-1 – Locations of IDOT District Headquarters

District	City	Address
1	Schaumburg	201 West Center Court
2	Dixon	819 Depot Avenue
3	Ottawa	700 East Norris Drive
4	Peoria	401 Main Street
5	Paris	13473 IL Highway 133, PO Box 610
6	Springfield	126 East Ash
7	Effingham	400 West Wabash
8	Collinsville	1102 Eastport Plaza Drive
9	Carbondale	State Transportation Building, PO Box 100

If the Station One is considered the equivalent of a district, then the statewide system will provide information sharing between the regions and the State DOT. An example of this exchange could include placing Amber Alert messages on the district's signs from Springfield.

In addition to the IDOT districts, the statewide communications system can be used to help share video and information between other agencies, including:

1) Illinois State Toll Highway Authority (ISTHA)
The ISTHA currently operates the Traffic Incident Management System (TIMS). Video is currently being shared by the ISTHA with IDOT District 1 and other agencies. It is envisioned that the Statewide Communications Network could be used to help share the ISTHA information with adjacent IDOT Regions.

2) Chicago Department of Transportation /Chicago Office of Emergency Management and Communications
The Chicago Department of Transportation (CDOT) and the Chicago Office of Emergency Management and Communications (OEMC) currently operate and maintain several traffic signal interconnects, or "smart corridors". These corridors include deployments of CCTV cameras at key intersections and arterial VMS at key decision points. In addition, the OEMC operates security cameras throughout the city. These cameras can also be used to monitor traffic on the arterials.

The OEMC also operates the City's Emergency Operations Center. It is anticipated that video from IDOT District 1 will be used for many of their operations. Likewise, video from their cameras would benefit IDOT operations.

3) Wisconsin Department of Transportation – MONITOR system
The Wisconsin Department of Transportation operates the MONITOR advanced freeway traffic management system throughout southeast Wisconsin. This system includes freeway CCTV cameras, variable message signs, ramp metering control, and travel information portals. It is anticipated that video and traffic information will continue to be shared between Wisconsin and Illinois through the GCM Gateway.

4) Missouri Department of Transportation - Gateway Guide (St. Louis)
The Missouri Department of Transportation (MoDOT) operates the Gateway Guide advanced transportation system throughout the St. Louis area. This system includes surveillance cameras, variable message signs, and highway advisory radios (HAR) east of the Mississippi River in IDOT District 8. The Gateway Guide website is www.gatewayguide.com.

5) Indiana Department of Transportation - Borman Expressway
The Borman Expressway (I-80/94) runs approximately 15 miles from the Illinois State Line to the Indiana Toll Road (I-90) in Lake Station and is part of a larger Northwest Indiana TrafficWise system. The ATMS covers approximately 21 miles of Interstate highway including the Borman Expressway and a six-mile stretch of I-65 from US 30 to the Borman interchange. The Borman system includes surveillance cameras, variable message signs, and traffic detectors east of the Illinois/Indian state line. It is anticipated that sharing video and traffic information between INDOT and IDOT District 1 will continue through the GCM Gateway. The Borman Expressway website is www.in.gov/dot/div/trafficwise/content/trafficwise/about_borman.html.

6) GCM ITS Priority Corridor Gateway
The Gary-Chicago-Milwaukee (GCM) Intelligent Transportation Systems (ITS) Priority Corridor includes a partnership between the Illinois Department of Transportation (IDOT), Indiana Department of Transportation (INDOT), and Wisconsin Department of Transportation (WisDOT). The GCM Gateway collects information from partnering agencies and disseminates it to the traveling public through of number venues including the GCM website at http://www.gcmtravel.com.

Routine and Emergency Operations

Different requirements exist between day-to-day operations and network operations under stressed or emergency operations. Normal operations are concentrated within regions and the information that flows out of the regions is typically informational. During stressed or emergency operations, the information being transported by the network typically addresses a larger geographical area and is operationally significant at a higher level in the Government. Accordingly, the network must be designed to provide its highest reliability under stressed conditions.

5.2.2 Information Requirements

Statewide ITS communication networks will allow partnering agencies to better share important traffic and ITS information, particularly in times of emergencies. Specific requirements may vary from district to district.

Information flows consist of both video and data, both into and out of a district. Information flows for a particular district may be symmetrical but in most cases will be asymmetrical.

The following information requirements form a baseline for a statewide communications network.

Video Requirements

Several IDOT districts have existing CCTV surveillance cameras including District 1, District 2, District 4, District 6, and District 8.

IDOT District 1, IDOT Central Office, and State Emergency Operations Center (SEOC) serve as central control hubs collecting and distributing CCTV video. Video flows for District 2, District 4, and District 8 will be mostly asymmetric with most video flowing outbound.

Other districts may have few if any CCTV cameras installed. The video requirements for these districts will be small, and any video flows will likely be outbound.

Table 5-2 summarizes the estimated video flows in and out of the IDOT districts and partnering agencies.

LOCATION	INBOUND VIDEO (from the Statewide system)	OUTBOUND VIDEO (to the Statewide system)
IDOT District 1 Comm. Center	2	4
IDOT District 2	2	4
IDOT District 3	0	2
IDOT District 4	2	4
IDOT District 5	0	2
IDOT District 6	0	2
IDOT District 7	0	2
IDOT District 8	2	4
IDOT District 9	0	2
Illinois GCM Gateway	4	12
SEOC	12	0
IDOT Central Office	2	0
Missouri Gateway Guide	2	2
WisDOT Madison	2	2
WisDOT Monitor	2	4
InDOT Borman Expwy	2	4
Chicago OEMC	12	4

Table 5-2 – Summary of Video Flows

Video requirements include:

- Support transmission of MPEG-2 and MPEG-4 encoded video.
- Support IP multicasting using Internet Group Management Protocol (IGMP)
- Support encoding and compressing legacy analog video
- Where appropriate, provide support for distributed control of PTZ cameras (This requirement may be included in the data requirements.)

Data Requirements

ITS data flows for most districts will be symmetrical with equal data flowing in and out of a district but will vary from district to district. District 1 and District 6 data flows will be the largest, followed by District 2, 4, and 8. The remaining districts will have smaller data flows.

Data requirements may include some or all of the following:

- Provide near real-time traffic conditions (travel times, vehicle speeds or traffic densities)
- Provide weather data
- Provide incident data
- Provide distributed control of VMS
- Provide distributed control of camera and video
- Transport emergency management information

- Transport public safety information
- Transport CVO information.

Operational Requirements

1. Internet

The Internet provides a means of communicating with the public, as well as a means of providing transport of operational data using a virtual private network (VPN).

2. Illinois 511 System

Information to support the Illinois 511 System will be aggregated by the Illinois Gateway. While the Gateway will use the Statewide Communications Network to access and retrieve data, it is not envisioned that the bulk of the 511 system will use the Statewide Network for normal operations.

3. Emergency Communications

Under the Incident Command System (ICS), it is anticipated that the amount of information emanating from the SEOC will be limited. The predominant use of the statewide network will be for inbound video from an affected area. This will provide "ground truth" visibility of an incident for those monitoring the situation in Springfield and provide better coordination of a statewide response.

4. Public Safety Communications

The bulk of the public safety communications reside within a district or region. As such, the Statewide network provides minimal capabilities to support these communications. It could be used as an alternate and diverse system to increase the overall reliability of their existing long-haul requirements to access inter-regional, State, and Federal databases.

Estimated Bandwidth Requirements

Video is the largest consumer of available bandwidth. Each video signal will typically use between three and six megabits per second. This is for a full-motion video image, with VGA quality (640 by 480 pixels). For smaller images, or for slower refresh rates, the bandwidth requirement can be decreased. However, these images are of less quality should only be used for systems that cannot provide adequate transmission rates.

Additional Requirements

The statewide communications network will be made up of both backbone communication links and access communication links. In addition to the requirements identified above, the statewide communication network should meet the following requirements:

1. Reliability

Reliability is a measure of the systems ability to support the operational requirements defined for the system on a continuous basis. It is usually expressed in three quantifiable terms, availability, mean-time-before-failure (MTBF), and mean-time-to-repair (MTTR).

The best options for increasing the level of reliability includes reducing the number of possible single points of failure. Redundancy, in either equipment hardware or network links, should be built into the network to reduce these single-points of failure.

Specific design criteria should be established for the system. Possible requirements include:

- Loss of a single backbone communication link shall not cause a loss of connectivity between any two nodes.
- The maximum time to restore the system shall not exceed two hours.
- Equipment at nodes should be supplied fro an uninterruptible power supply (UPS) and shall include independent power supplies.

2. Maintainability
The maintainability of a system addresses the capability for agency technicians to keep the system operating at as-installed conditions and to restore the system to normal operations following an equipment failure. It addresses the need for documentation, test equipment, and the skill set for personnel.

For the statewide network, the issue becomes one of ownership. If the State owns the network and transmission equipment, they are responsible for the maintenance of the equipment. This can be accomplished by contracting to local vendors and installers.

There is also the option of leasing services through a service provider. Using this approach, maintainability becomes the responsibility of the service provider. The downside is that the service provider determines the quality of the maintenance and the availability of the network. For rural areas, service outages may be extremely long at times. There is also the potential issue of recurring funding to cover the lease periods.

3. Supportability
Supportability addresses the ability of the maintaining agency to obtain replacement modules and to obtain updated system documentation. Inherent in supportability is configuration management. Configuration management documents the versions of the software and equipment modules that are currently installed. It also provides a documented path for upgrades to retain compatibility of system components,

4. Scalability
Scalability defines the ease of incrementally building the system into its final configuration. Scalability is the feasibility of designing a network for the ultimate requirement while only deploying the portion of it that addresses the immediate requirement.

5. Expandability
Defined as the degree to which the network can be upgraded in the future to meet changing requirements. It is a relative indication of incremental costs associated with the need to maintain or replace the existing infrastructure based on increasing requirements.

For the statewide network, the best opportunity of expanding the network in the future is to build it around equipment that designed to American National Standards Institute (ANSI) standards. These are consensus standards that are accepted throughout the industry. Most equipment built to these standards operates with equipment built by other manufactures that is also designed to these standards.

In addition, the technology itself is being "expanded" in future equipment. This equipment typically supports legacy equipment. Thus, while today Gigabit Ethernet equipment is available, there is already equipment being designed for 10 Gigabit Ethernet and beyond. The key is that this equipment provides the same 100Base-T interfaces that are used today.

6. Security
For ITS networks, security addresses issues of privacy, regulated access, and eliminating malicious activities. Typical issues include:

- Keeping personal information of users private.
- Preventing public access (intentional or non-intentional) to ITS and network components. This includes field equipment (such as cameras or VMS), workstations, servers, and network equipment.
- Providing firewalls and requiring authentication and authorization to preclude access to databases and sensitive information from the Internet from unauthorized users.

5.3 Operational Models

5.3.1 A. Basic Operational Architecture

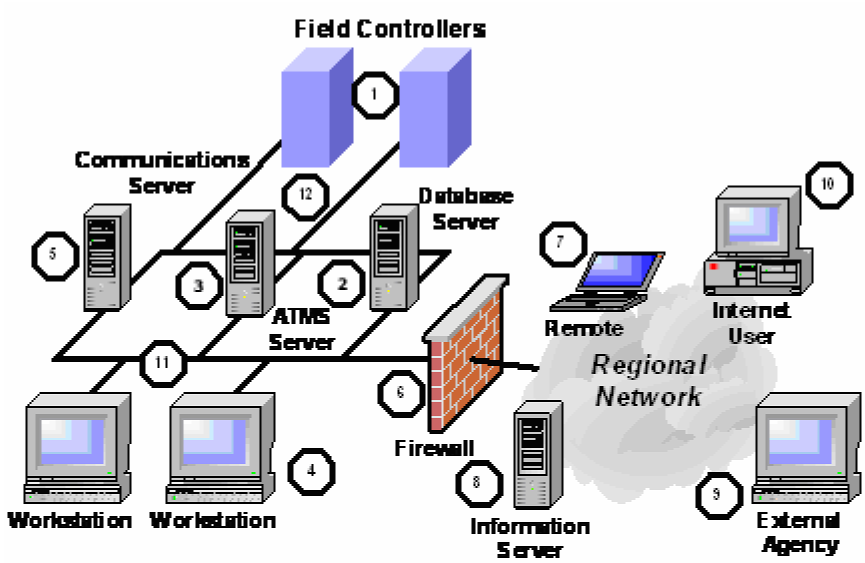
This section outlines the basic Statewide ITS communication system operational architectures including intra-district communications, inter-district communications, and inter-district operations.

Intra-district Communications

A typical communications deployment model for intra-district communications is depicted in Figure 5-1.

It should also be noted that the Statewide Communications Network is not focused on Intra-district communications. The actual intra-district communication network is unique to each district or region. The communications technologies should be selected to optimize the performance in that district and to minimize the overall construction and maintenance costs. They should be determined and standardized within the district.

Figure 5-1 – Intra-district Communications



A typical intra-district communication model may consist of the following elements:

1. Field Controllers

The field controllers represent the ITS field elements. These elements can be collecting traffic information, such as vehicle detector stations or CCTV camera sites, providing traffic information to the traveling public, such as dynamic message signs or highway advisory radios, or controlling traffic such as traffic signals or ramp meters.

2. ATMS server

The Advanced Traffic Management System (ATMS) Server provides the system logic and automation processes. It includes algorithms that monitor the traffic data stored in the database server and produces events that trigger responses from either the operator or the field equipment. Some of the responses may be automated and others may require operator intervention.

3. Database Server

Each ATMS has some form of data repository to store the traffic data retrieved from the field, response plans, standard message sets, and system configuration data. Some of this information may be collected manually and some may be automated.

4. Workstations

The workstations represent the system interface to the operators at the operations centers. These workstations can access the ATMS and database servers through a desktop client-based software application. Alternatively, access to the servers and data could be through a browser-based client interface. For limited functionality, a personal digital assistant (PDA) or handheld computing device can be used for notifications and limited control of devices.

5. Communications Server
The Communications Server provides the processes and drivers to communicate between the servers and both the field equipment and the operators' workstations. These servers should be migrating to protocols that are compliant with the National Transportation Communications for ITS Protocols (NTCIP) and other standard network-communications protocols such as TCP/IP.

6. Firewall
The firewall provides security between the internal and external networks. For a totally private network that does not have any external network connections, this element is not required. However, if there are external network connections to other outside networks (such has an external agency's network or the Internet), this is a necessary component.

7. Remote Users
Remote users are considered operators that may operate the network from remote locations. This could include system maintainers or operators that can monitor or operate system elements from their home during the hours that personnel are not present at the operations center.

8. Information Provider
The information provider represents an entity that collects data and information and republishes it as a central clearing house. This could be a public or private entity. An example might include an entity that collects traffic data and publishes travel times to an Internet webpage.

9. External Agencies
External agencies connect to the ATMS to share traffic information and video. These agencies can connect directly to the network, through the firewall, and obtain the information from the information provider and/or Internet website.

10. Internet Users
Internet users obtain traffic information from a web page hosted on the Internet. This site can be one created and maintained by the agency that operates the ATMS, or it can be one that was created and maintained by a third party information provider.

11. Front side network
The front side network connects the servers and the workstations. It has typically been some form of an Ethernet network, again using standard networking protocols to communicate.

12. Backside network
The backside network provides communications between the ATMS and the field equipment. In the past, this typically has been dial-up circuits on the public switched network or multipoint modem circuits on a privately owned cable network. Using modern technology, today's networks are extensions of a local area network (LAN), using the Internet Protocol (IP) to address and communicate with the field controllers.

Not every system contains these elements as separate entities. In some advanced traffic management systems, as capacity and processing requirements permit, these functions could be combined on a single workstation.

<u>Inter-district Communications</u>

The basic concepts for use of the Statewide Communication Network in inter-district communications, as depicted in Figure 5-2, include the following:

1. Interconnecting intra-district networks

The primary use of the statewide communication network will be to interconnect the intra-district networks that were discussed in the previous section. This would enable the exchange of information between districts. Routers are used at the interface to the network. These routers provide isolation between the district networks and the statewide ITS backbone network, as well as additional security. It is envisioned that the routers could include an embedded firewall.

As depicted, it would also allow an information server (gateway) in one district or region to retrieve information from another district or region. Thus, the statewide communication network could provide communications for the Illinois Gateway Hub to collect information from other ITS districts in the state. The gateway would then publish the information using its existing communications. Other districts could access the information using the statewide communication network or the Internet.

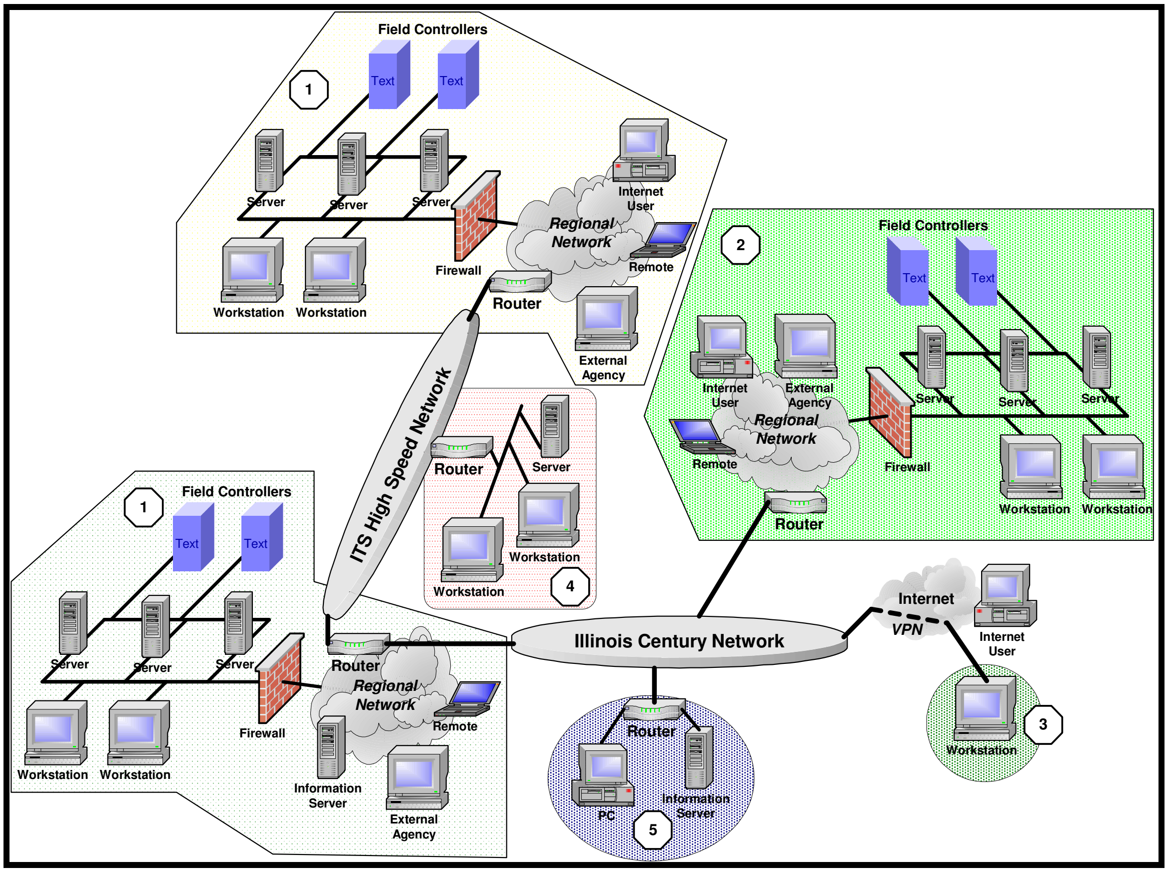


Figure 5-2 – Model of Inter-district Communications

2. Interconnecting intra-district networks

The primary use of the statewide communication network will be to interconnect the intra-district networks that were discussed in the previous section. This would enable the exchange of information between districts. Routers are used at the interface to the network. These routers provide isolation between the district networks and the statewide ITS backbone network, as well as additional security. It is envisioned that the routers could include an embedded firewall.

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3. Connecting through the Illinois Century Network (ICN)

Where a district is not geographically located close to a statewide communication backbone, it is envisioned that the Illinois Century Network (ICN)[1] could be used for communications. By providing an interface to the network from one of the districts, any district connected to that

[1] The Illinois Century Network is discussed more extensively under Section 5.4 Section D.

region via the ITS backbone would also be accessible through the ICN. The ICN website is www.illinois.net.

4. Connecting through an Internet Service Provider

The ICN is linked to the Internet through several providers. For districts that do not have direct access to statewide communication network and could not justify the cost of linking to the ICN, it would be technically possible to establish a virtual private network (VPN) through any Internet provider. This would allow all districts or work centers to access statewide ITS information. More important, the multiple interfaces would provide additional reliability.

5. Connecting the IDOT Central Office

It is envisioned that the IDOT Central Office would also link to the network using a router. This connection would provide State agencies access to the information on the network. The State node could also be used for linkages to the ICN.

6. Connecting universities and other research institutions

By using the ICN as a communications element in the Statewide Communications Network, there is an added benefit for universities and other institutions desiring the ITS data for research. It should be possible for these institutions to access the data through the statewide network as they are already connected to the ICN.

Inter-district Operations

There are multiple scenarios for sharing ITS hardware control between several districts including:

- In the simplest construction, a remote computer in an adjacent district could control the ITS system. The communications would use the same concepts as those within the district, utilizing the capabilities of the extended network to access and control the devices through the advanced traffic management system.

- Another approach would be to use center-to-center communications to control the devices. Using this approach, the ATMS of one district would send a request/command to an adjacent district's ATMS. Based on the permissions assigned, the adjacent district's ATMS would initiate the proper response.

- As depicted in Figure 5-2, there are two networks associated with the ATMS. As more field equipment adopts the IP addressing, it will be possible to merge the physical media of the two networks. When this happens, it will be possible to control an adjacent district's equipment by merely knowing the equipment's IP address and having the proper authorization to pass through the firewall.

None of these methods of sharing control require a different communications model or architecture. The only issues are associated with the system software and interfacing.

5.4 Existing Public-Communications Infrastructure in Illinois

5.4.1 Overview of existing systems

Overview and Introduction to OSI model

The Open Systems Interconnection (OSI) Reference Model is an international conceptualization of interconnecting open network systems and their interfaces. The idea is that compatible standards and protocols need to be developed across the layers. It is not necessary for systems to be identical as long as they are compatible at the appropriate layers and can communicate to the layer above and below.

A similar model has been developed for the NTCIP standards. This is a five-layer model including Information, Application, Transport, Subnetwork, and Plant Levels. The lower three layers are depicted in Figure 3. This drawing deviates from the original by showing a linkage between the Ethernet and SONET. It also identifies "Telco Line" as "Leased Plain Old Telephone Service (POTS)." The reason for these deviations is changes in the way the technology is being applied. Ethernet over SONET is very common in many ITS applications.

Likewise, it is no longer a safe assumption that a "telephone line" will be provided by a "traditional telephone company." There will be a continued trend for cable companies and Internet service providers to add voice circuits to their offerings.

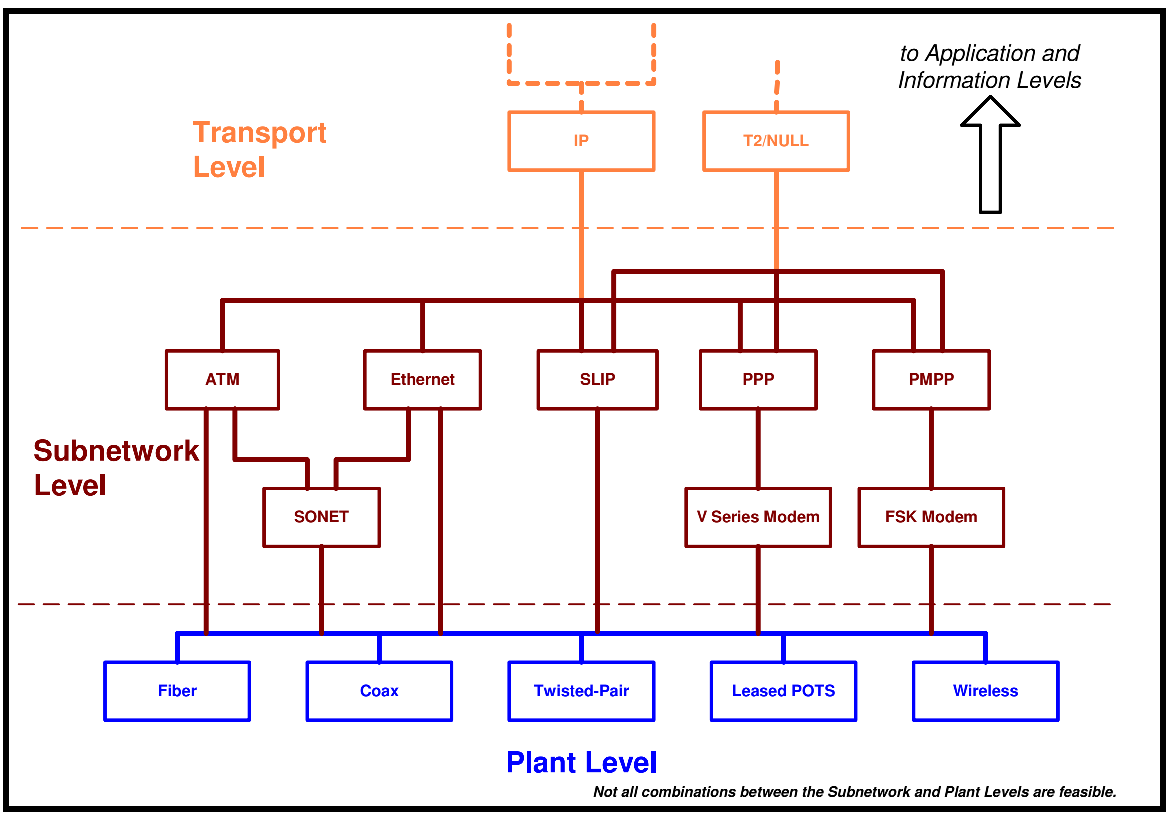

Figure 5-3 – NTCIP Interface Model

In reality, there should be two additional boxes in the Plant Level, “Leased Broadband” and “Leased Wireless.” Leased broadband exists today with cable modems and digital subscriber lines (DSL). The cellular digital packet data (CDPD) services are being replaced with newer wireless data services. While these services are just beginning to be available in key markets, they will offer alternatives to the traditional wire-line services.

From the perspective of this document, the important concept is that network communications cannot be viewed from a single perspective. It must be viewed as different functional pieces that allow user-to-user communications.

IDOT ITS Communication Systems Inventory

IDOT owns or has access to (through agreements with other agencies) fiber optic cable in many sections of the state, primarily in IDOT District 1. Below is an inventory of existing known IDOT ITS communication systems.

1) IDOT District 1

Plant Layer

IDOT District 1 currently maintains a SONET data and video network using a mix of fiber optic and microwave links. The fiber optic links use a combination of state owned and IDOT accessible fiber optic cable.

The IDOT District 1 fiber optic network includes:

- 96-fiber single-mode cable installed from the Circle Interchange communication shelter to the Traffic System Center along I-290
- 96-fiber single-mode cable installed from the Traffic System Center to the Hillside communication shelter along I-290.
- 96-fiber single-mode cable installed from the Circle Interchange communication shelter to the I-55/90/94 fiber optic termination point along I-90/94.
- 48-fiber single-mode cable installed from the I-55/90/94 termination point along I-55.
- 48-fiber single-mode cable installed from the I-55/90/94 termination point to Martin Luther King Drive along I-55.
- 96-fiber single-mode cable installed from the I-57 communication shelter to the I-57/I-294 interchange along I-57.

Ongoing or future projects will install additional fiber optic systems including:

- 96-fiber single-mode cable installed between approximately the Illinois/Indiana state-line and the I-294/I-80 interchange as part of the I-80 reconstruction project.
- 96-fiber single-mode cable installed from a new I-55/90/94 communication shelter to the existing I-57 communication shelter along the I-90/94 Dan Ryan Expressway.

See Figure 5-4 for a summary of IDOT communication systems in northeast Illinois.

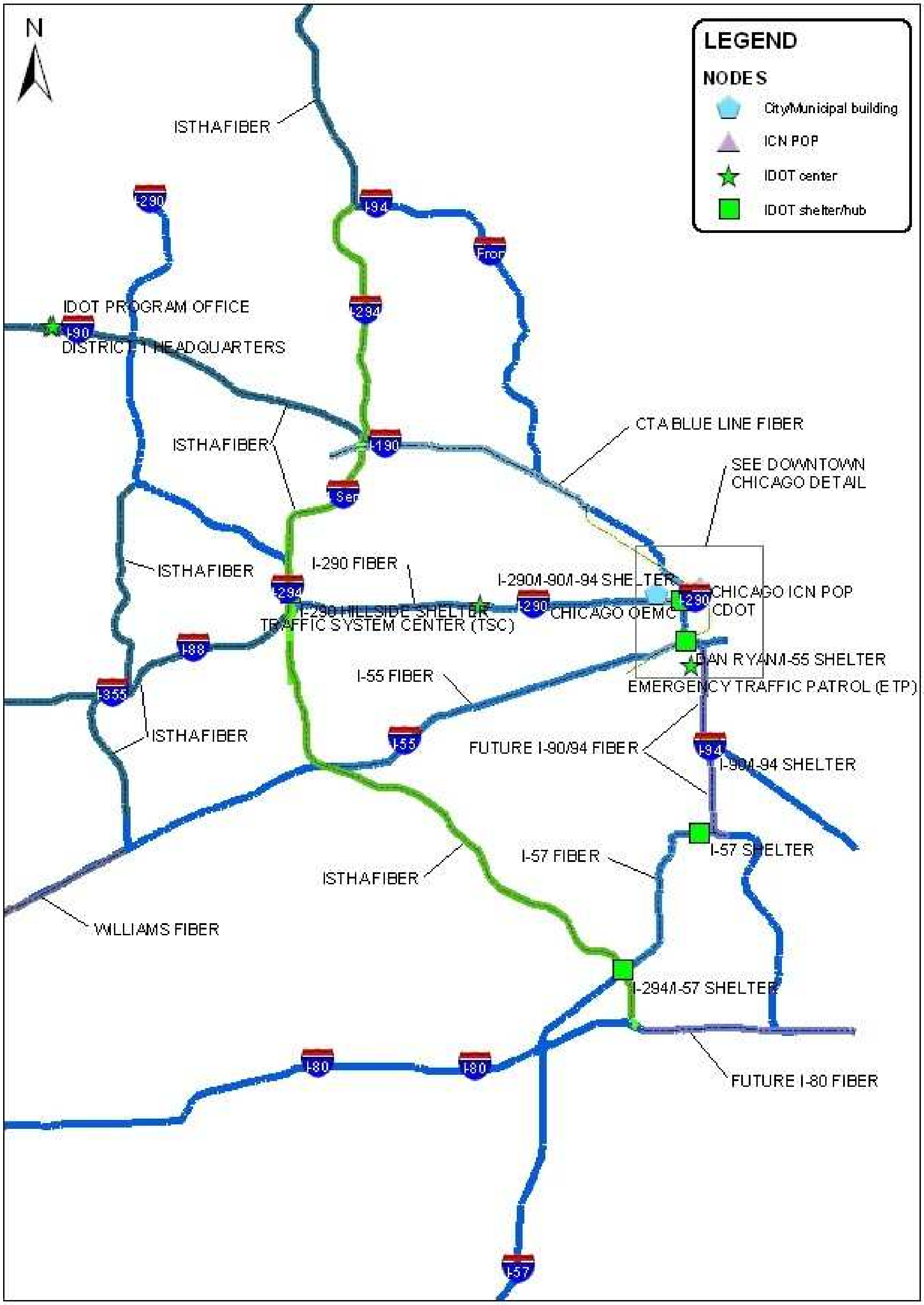

Figure 5-4 – IDOT District 1 Communication Inventory

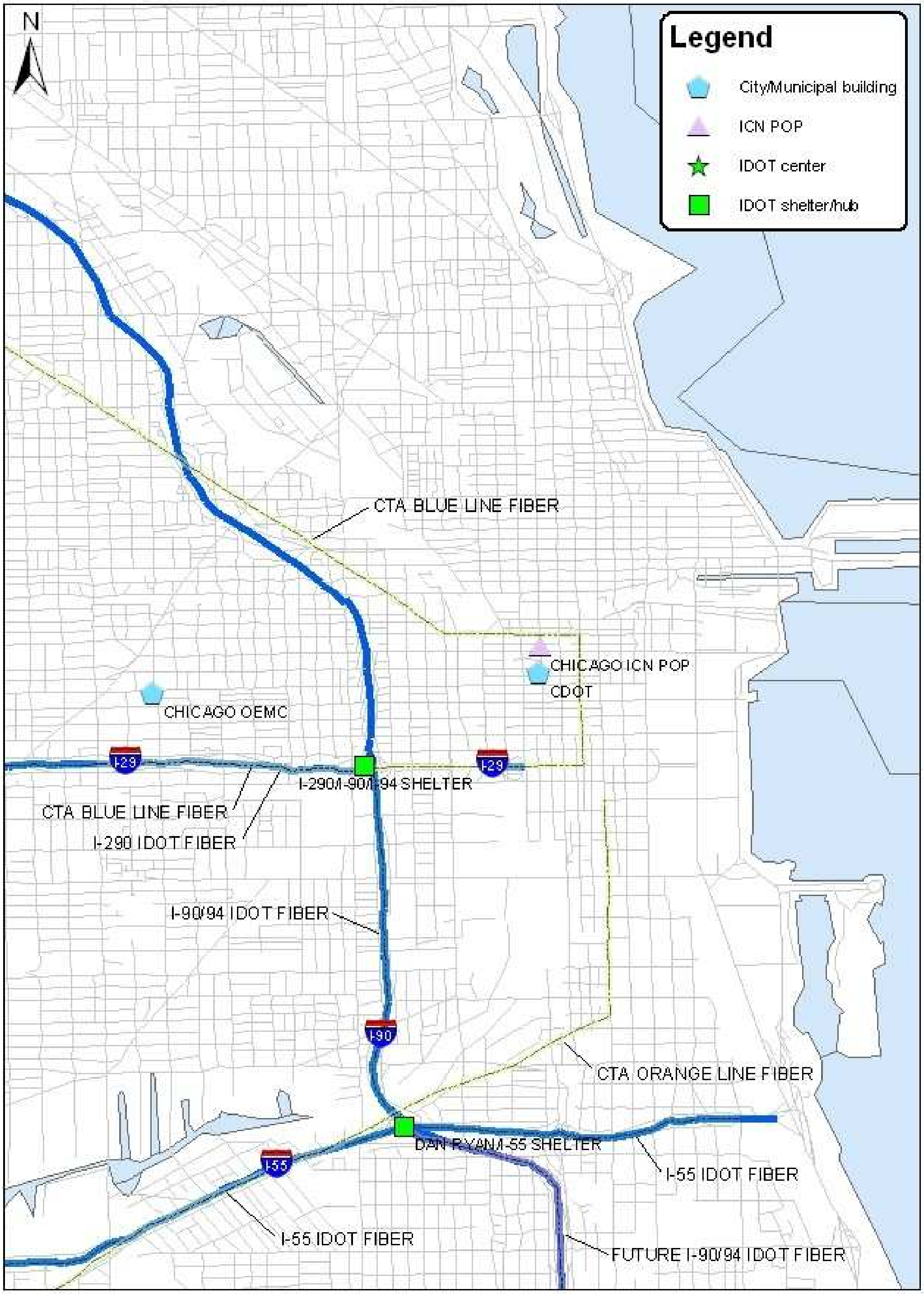

Figure 5-5 – IDOT District 1 Communications Inventory (Chicago)

Subnetwork Layer
As previously identified, the District 1 communications system uses a combination of Gigabit Ethernet and SONET rings to provide high-reliability communications. The Gigabit Ethernet provides a common broadband interface for all field equipment. The SONET rings are self-healing and provide rapid circuit restoration during equipment failures or cable cuts. For most regions, the rapid "self-healing" would not be required. It is required in District 1 due to their use of reversible lanes. The safety issues associated with these lanes and the control elements require the highest reliability.

2) IDOT District 2

Physical Layer
There is no known IDOT owned, single-mode fiber optic cable installed in the Dixon area. As shown in Figure 5-6, the ISTHA has fiber optic cable installed along I-88 extending west past Dixon. IDOT has indicated that there is also a proposal to install single-mode fiber optic cable along I-39 between I-88 and Rockford. This could provide connectivity to other regional assets.

The City of Rockford has acquired access to two single-mode fibers from a Metro Fiber Solutions (MFS) fiber optic cable installation in approximately 1995. Rockford leases the two fibers from MFS for a monthly leasing fee. Additional fiber installation by the City of Rockford to interconnects downtown municipal buildings including the City Hall and Public Safety Building creating the City of Rockford "RockNet" communication system.

As part of Operation GreenLight, IDOT has also installed a traffic signal interconnect along State Street from Fairview Boulevard to University Drive. While the installed multi-mode fiber optic cable would not be applicable to a statewide ITS communication network, the installed conduit may be useful for future fiber installations connecting the ISTHA fiber along I-90 with the existing "RockNet" system.

See Figure 5-6 for a summary of IDOT District 2 communication infrastructure inventory.

Subnetwork Layer
The City of Rockford "RockNet" communication system is a Gigabit Ethernet network used to connect several city facilities including the county sheriff's office, Rockford Police department, and City Hall.

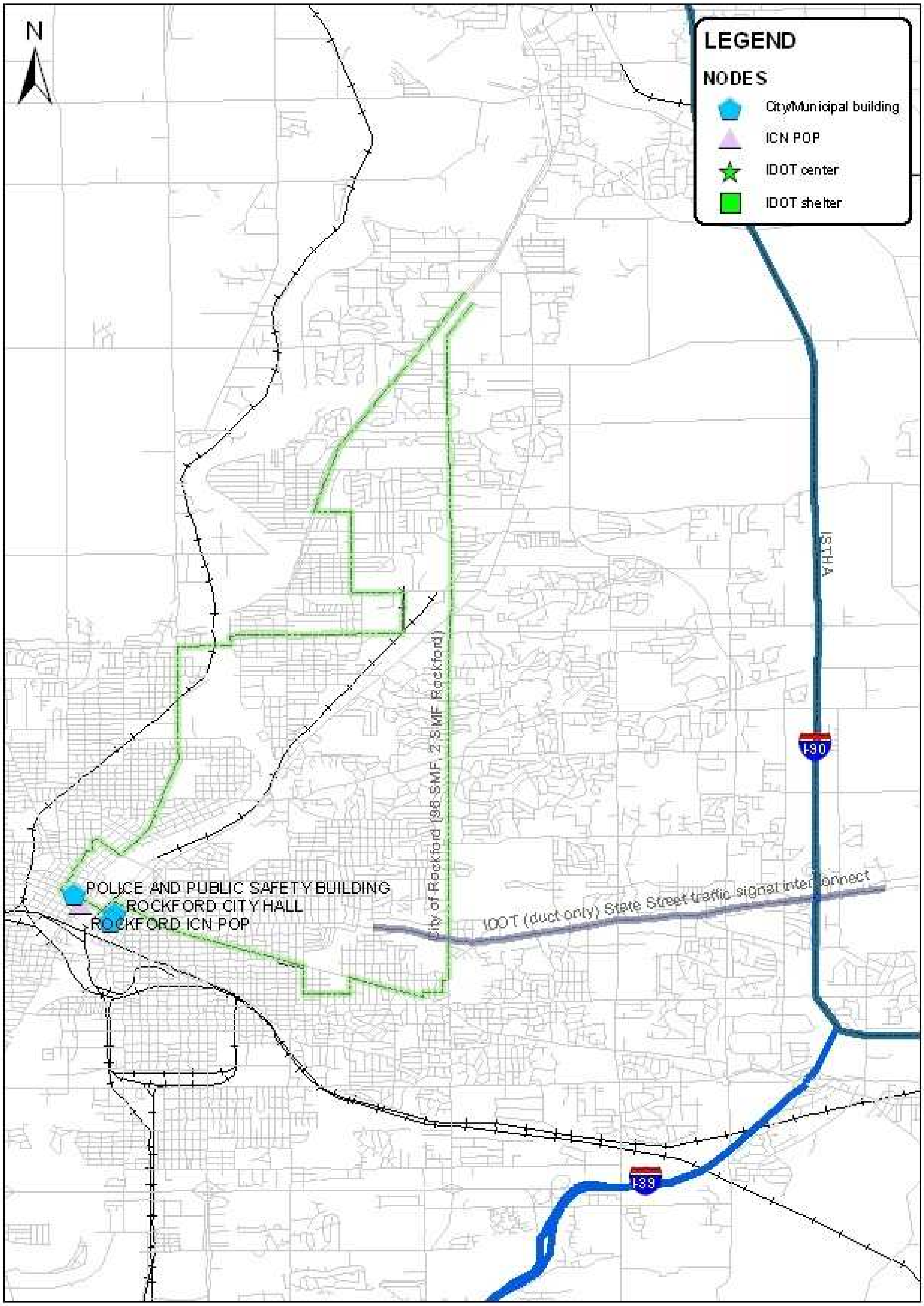

Figure 5-6 – IDOT District 2: City of Rockford Communication Inventory

3) IDOT District 4

Plant Layer

District 4 maintains a combination of wireless and fiber optic communication networks recently deployed as part of the I-74 reconstruction project. Single-mode fiber optic cable has been installed along I-74 and through parts of downtown Peoria to connect the District 4 headquarters to the City of Peoria Department of Public Works at Dries Lane and City of Peoria Emergency Communications Center. The 2.4 GHz , 5.2 GHz, or 23 GHz microwave wireless links connect many ITS field elements with the District 4 TOC.

The Williams Communication fiber runs south along I-55 from the Chicago area to Chenoa where the fiber turns west and runs along US-24. The fiber continues west to Peoria where it eventually intercepts I-74. The fiber runs along I-74 east to IL-121 where it then runs south until it eventually rejoins I-55 in Lincoln.

See Figure 5-7 for a summary of IDOT District 4 communication system inventory.

Subnetwork Layer

The IDOT District 4 communication system uses Ethernet to interconnect agencies and to provide links with field ITS elements.

4) IDOT District 6

Plant Layer

The Williams Communication fiber installed along I-55 from Chicago to St. Louis also runs through part of downtown Springfield.

Subnetwork Layer

IDOT uses a combination of Gigabit Ethernet and leased connections to provide links with field ITS elements.

See Figure 5-8 for a summary of District 6 communication systems inventory.

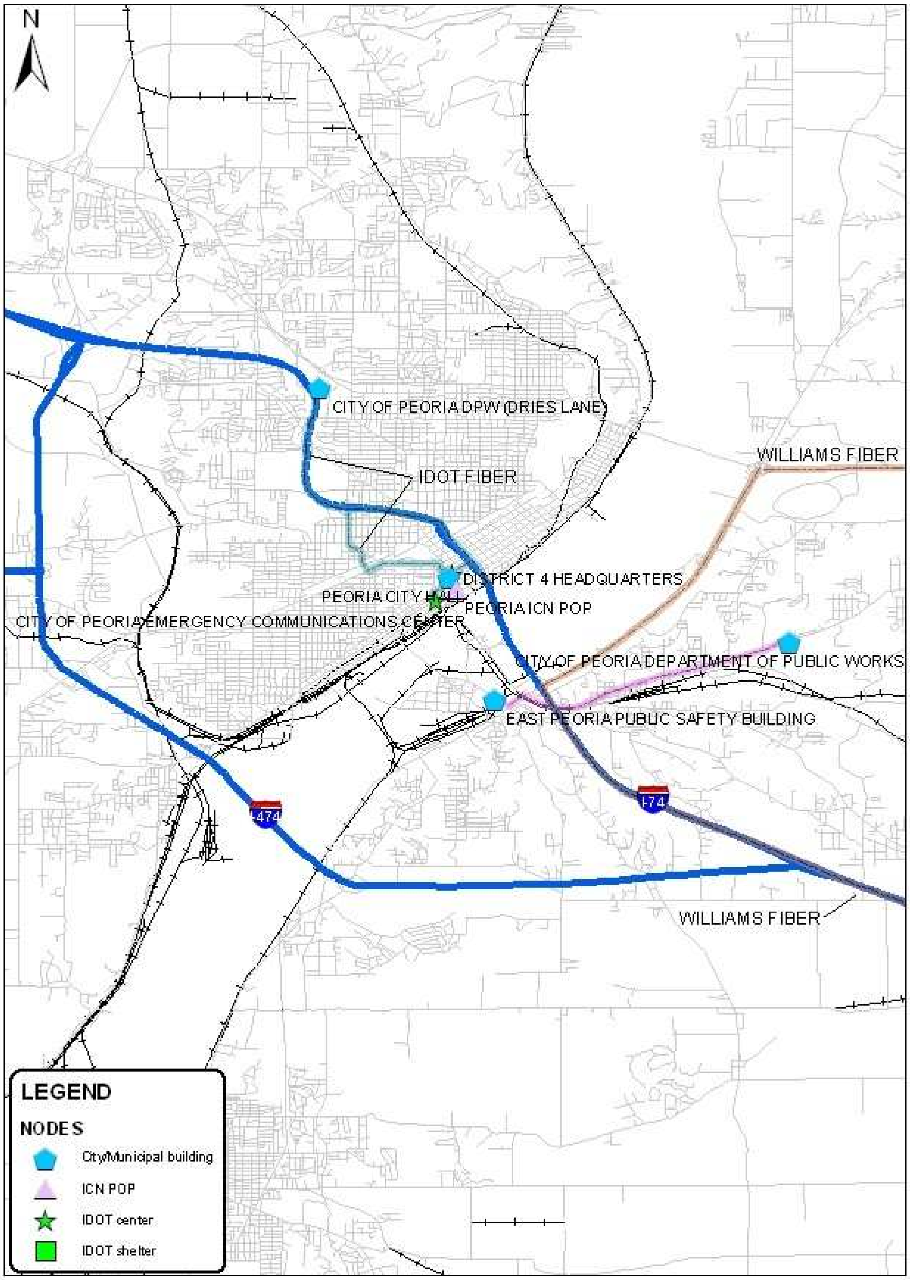

Figure 5-7 – IDOT District 4 Communication Inventory

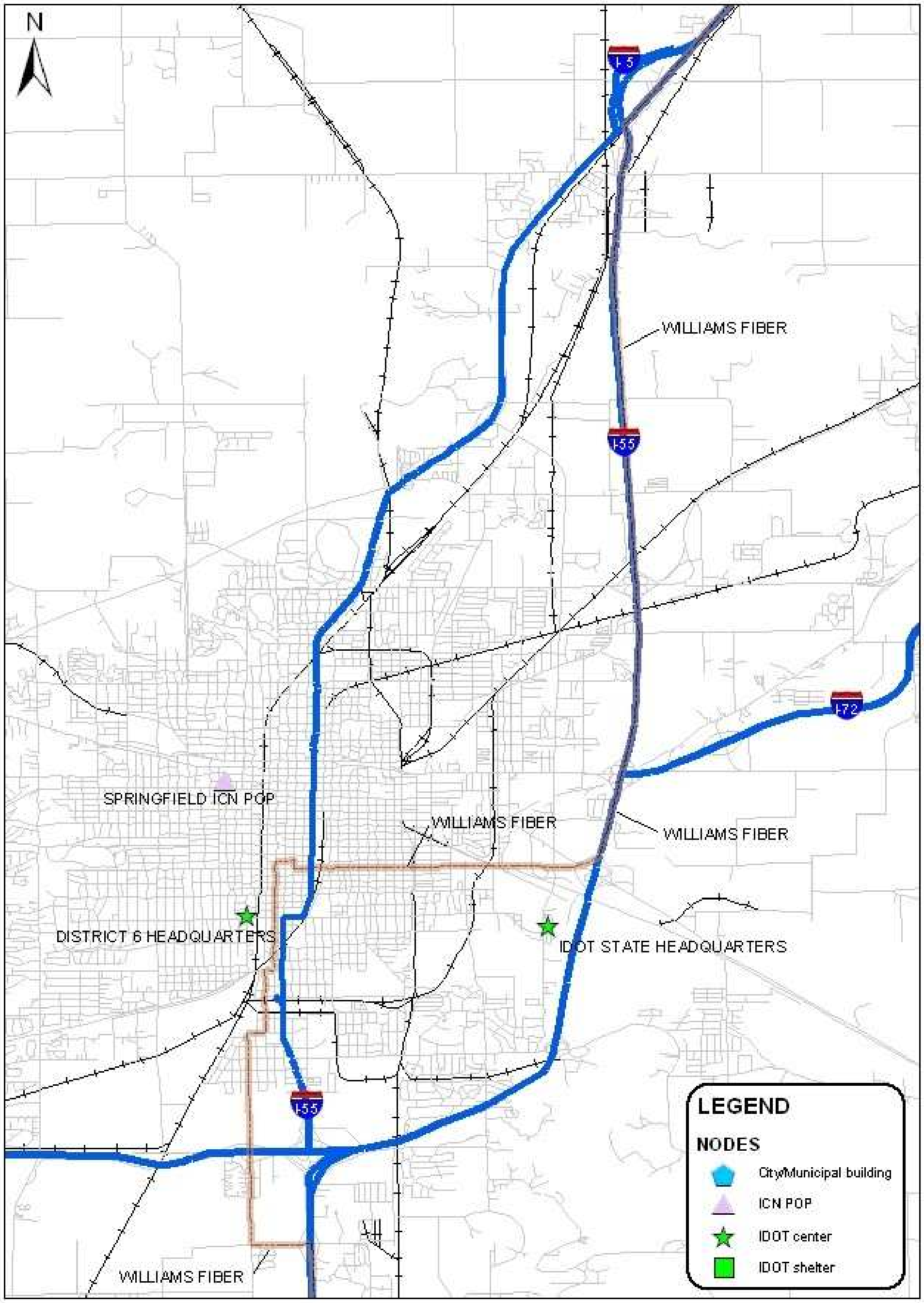

Figure 5-8 – IDOT District 6 Communication Inventory

5) IDOT District 8

Plant Layer
At the time of this study, there was no IDOT owned, single-mode fiber optic cable installed in District 8. The Williams Communication fiber installed between Chicago and St. Louis runs south along I-55 and then west along I-270 towards St. Louis past the I-255/I-270 interchange.

Current field elements use leased communications to connect back to the District 8 TOC. In particular, CCTV video cameras are connected to the IDOT District 8 headquarters using leased T1 connections and DMSs use dedicated leased telephone connections.

See Figure 5-9 for a summary of District 8 communication systems inventory.

5) I-55 fiber

As discussed previously, Williams Communications has a 96-fiber single-mode optical cable along I-55 running from Chicago to St. Louis passing through both Peoria and Springfield. In an agreement with Williams Communications, IDOT has access to 8 of the 96 fibers.

<u>Other Systems</u>
There are other agencies that operate communication systems that may augment the statewide communication system.

1) ISTHA

The Illinois State Toll Highway Authority (ISTHA) currently maintains an extensive fiber optic based SONET system with fiber optic cable installations along each tollway. In total, the ISTHA maintains five (5) SONET ring networks providing support for Gigabit Ethernet network connections.

In agreements between IDOT and the ISTHA, IDOT has access to four (4) fibers along ISTHA tollways east of the Fox River, and two (2) fibers along ISTHA tollways west of the Fox River. Of the four (4) fibers east of the Fox Valley, two are reserved for GCM ITS integration purposes and two are reserved for IDOT District 1 for discretionary use.

2) City of Chicago/CDOT/Chicago Emergency Management

The Chicago DOT, now OEMC TMA, established several smart corridors south of the City in the vicinity of Midway Airport. These smart corridors use hybrid multi-mode and single-mode fiber optic cables to support a combination of digital data and analog video multiplexed communication systems. These networks transport data from traffic signal controllers and video from CCTV cameras. Future smart corridor design is migrating to digital technology including MPEG CCTV video codecs and networks based on Ethernet standards.

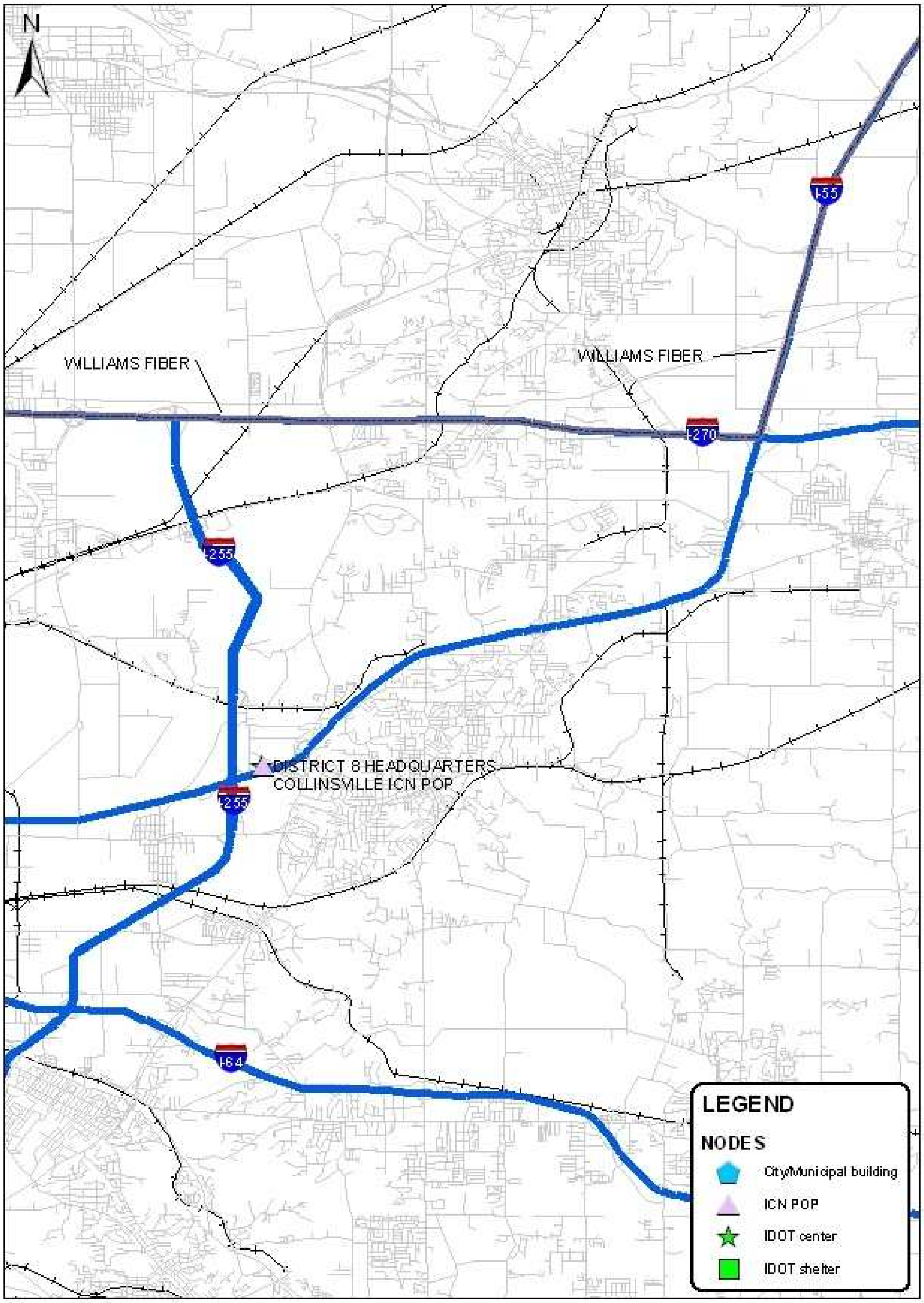

Figure 5-9 – IDOT District 8 Communication Inventory

In addition, the City of Chicago has optical fibers extending throughout their domain as part of the Chicago Transit Authority's communications system. They could provide additional access to State and Municipal agencies located in the central business district.

5.4.2 Statewide Academic Networks (Illinois Century Network)

The Illinois Century Network (ICN) is a telecommunications backbone providing high speed access to data, video, and audio communication in schools and libraries, at colleges and universities, to public libraries and museums, and for local government and state agencies. The ICN provides the backbone network, the point of presence equipment (central equipment necessary to connect to the network), and a predetermined amount of baseline Internet access to eligible constituents. Participants are responsible for the customer premise equipment (CPE) and any necessary access circuits.

The ICN backbone provides multiple diverse routes to the Internet in different parts of the state to ensure reliability and redundancy. The backbone is built on an OC12 ring that extends from Chicago-Peoria-Springfield-Champaign with OC3 and DS3 rings extending to other areas of the state. Internet egress is procured through five unique providers with routes leaving the network at three diverse locations. The ICN also provides connectivity to Internet2 through an OC12 to StarTrap/MREN.

The ICN has established nine Regional Technology Centers staffed with certified network specialists strategically located throughout the state to provide regional service as needed. There is also a Network Operations Center in Springfield to handle after-hour calls.

The ICN is governed by a Policy Committee with seven standing members representing the Board of Higher Education, the Community College Board, the State Board of Education, the State Museum, the State Library, the Department of Central Management Services, and the Governor's office.

See Figure 5-10 for an overview of the primary ICN network links.

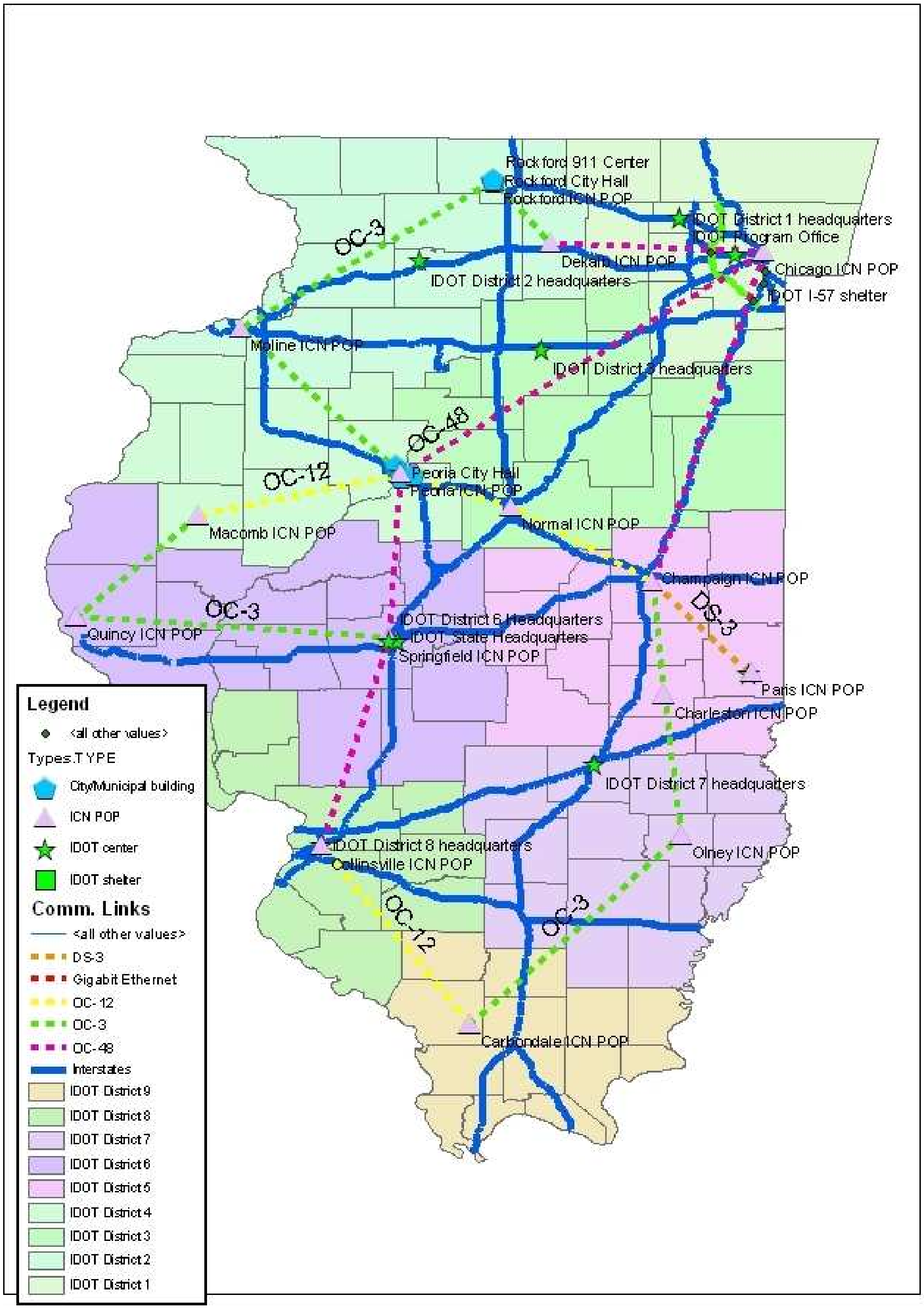

Figure 5-10 – Illinois Century Network

Table 5-3 contains the ICN points-of-presence (POP) located strategically throughout the state of Illinois.

City – POP site	Address
Carbondale	1255 Lincoln Drive
Champaign	202 East Peabody
Charleston	805 7th Street
Chicago	160 North LaSalle
Collinsville	1100 East Port Plaza Drive
DeKalb	1425 West Lincoln Highway
Macomb	1 University Circle
Moline	3561 60th Street
Normal	506 University Street ISU – Cook Hall
Paris	228 North Central
Peoria	211 – B Southwest Adams
Quincy	1301 South 48th
Rockford	200 South Wyman
Springfield	201 West Adams

Table 5-3 – ICN POP Locations

5.4.3 Current IDOT Network – Central Office Infrastructure

Current operations link each IDOT district to Springfield using an existing network link. The bandwidth of these links varies from district to district depending on the particular district's requirements. These network links and the existing IDOT network serves many purposes including transporting general IDOT data (such as email). In the future, these links could be integrated into the Statewide network.

5.4.4 Illinois Mutual-Aid Networks

For most public safety communications, the Federal Communications Commission (FCC) assigns a specific frequency to an agency for its internal use. To avoid interference, this frequency is not assigned to other agencies in a given geographical proximity of the frequency's owner.

To allow agencies to communicate with each other, the FCC has established specific frequencies in the Public Safety spectrum that can be used for this communication. The licensing for these frequencies is usually restricted to the specific type of agency such as public safety or fire.

Within Illinois, several of these frequencies are used for communications between agencies. Some are used base station to base station, some are used for base stations to mobiles, and some are used mobile to mobile.

Public Safety (Law Enforcement)

The primary mutual aid frequency for public safety is 155.475 and is known by the acronym of ISPERN which stands for Illinois State Police Emergency Network. This is the primary frequency used by the ISP dispatchers to communicate with other municipal and county law enforcement agencies. The frequency of 155.370 has been established as the point-to-point frequency to be used to interconnect public safety base stations.

Frequency	Name	Purpose
154.265 MHz	IFERN	Mutual Aid base/mobile dispatch
153.830 MHz	Red Fireground	Fireground Operations
154.280 MHz	White Fireground	Fireground Operations
154.295 MHz	Blue Fireground	Fireground Operations
153.8375 MHz	Gold Fireground	Fireground Operations
154.2725 MHz	Black Fireground	Fireground Operations
154.2875 MHz	Gray Fireground	Fireground Operations
154.3025 MHz	IFERN2	Alternate mutual aid base or mobile
155.055 MHz	IREACH	Interdisciplinary Coordination

Table 5-4 – Interagency Frequencies for Fire Response

Fire

The Mutual Aid Box Alarm System (MABAS) enables Fire Departments to share resources by assisting each other as requested. The primary frequency used by these responders is 154.265 MHz, assigned as the Interagency Fire Emergency Radio Network (IFERN). The MABAS Committee is encouraging all apparatus that has the potential of responding to a MABAS or IEMA disaster, should have one mobile and one portable transceiver capable of operating on the frequencies identified in Table 5-4.

The Illinois Department of Public Health has established a requirement for all ambulances to have VHF-High band capabilities on the statewide MERCI frequency of 155.340 MHz using a private line (PL) tone of 210.7 Hz.

Interagency (IREACH)

The previous mutual aid frequencies require licensing as a public safety agency and are typically limited to one discipline. To bridge the gap, the Illinois Radio Emergency Channel (IREACH) was established. Operating at 155.475 MHz, IREACH was primarily established for mobile-to-mobile communications between interdisciplinary responders. Limited base stations are authorized to be licensed. As a minimum, these base stations must provide dispatching for two or more of the authorized disciplines. This frequency cannot be used by an agency for routine dispatching.

STARCOM21

STARCOM21 is a private, statewide trunked communications system provided by Motorola under a User Advisory Committee. Motorola provides the network communications facilities. The committee provides public access at the State and local levels to recommend policy and improvements. The State has a requirements contract with Motorola to provide equipment and leased service. The leased services are on a monthly basis and the charge is per radio.

The Illinois Terrorism Task Force is distributing STARCOM radios to public safety agencies throughout Illinois. These radios will be used for:

- Notification of change to the Homeland Security Threat Advisory System from the State Emergency Operations Center (SEOC)
- Monthly statewide tests
- Exercises (quarterly or approved in advance by the STARCOM21 Systems Operation Manager)
- Notification from the SEOC about incidents
- Communications en route while responding to an incident

For communications at an incident, the responders will be directed to a different talk-group and there will be an additional charge of $53 per radio for each 30-day period.

The STARCOM21 system is envisioned as providing land mobile radio (LMR) with excellent area coverage, with modern technology, at an affordable price for agencies throughout Illinois. Using its trunked radio system, it should be possible to include shared talk-groups on each agency's radio that could be used during a shared response to and incident.

5.5 Developing a Statewide Communications Vision

5.5.1 Potential Network Technologies

SONET

Developed to ensure compatibility at the interface between equipment from different manufacturers and being operated by different providers, SONET is the American National Standards Institute (ANSI) standard for synchronous point-to-point data transmission using optical fibers as the transmission medium.

SONET assigns a fixed bandwidth to each requirement, whether or not there is a demand for the bandwidth at a given time. It thus provides full assigned bandwidth under all conditions.

There are additional methods that further share the bandwidth between users. Typically, these systems use "packets" to transport the information. The most popular packet-switched methods include the Ethernet and the Asynchronous Transfer Mode (ATM).

SONET transmits the data in fixed format frames that assign positions to payload and overhead bits of information. Each SONET frame can be considered to be a two dimensional table of bits that is 9 rows high and 90 columns wide.

Table 5-5 summarizes the signaling rates of the different optical carriers. The line rate is the transmission rate that is launched into the optical fiber; the payload bandwidth is the amount of data that can be accessed at the data ports on the user-side of the transmission equipment. SONET transports circuit-switched data in frames at speeds of multiples of 51.84 Mbps up to 77 Gbps.

Optical Carrier Level	Line rate	Payload bandwidth
OC-1	51.840 Mbps	48.960 Mbps
OC-3	155.520 Mbps	150.336 Mbps
OC-12	622.080 Mbps	601.344 Mbps
OC-24	1,244.160 Mbps	1,202.688 Mbps
OC-48	2,488.320 Mbps	2,405.376 Mbps
OC-192	9,953.280 Mbps	9,621.504 Mbps
OC-768	39,813.120 Mbps	38,486.016 Mbps

Table 5-5 – Optical Carrier Transmission Rates

Asynchronous Transfer Mode

Asynchronous Transfer Mode (ATM) is a dedicated connection technology that switches data using a 53-byte cell and transmits the cells over a physical medium using digital signal technology. Individually, a cell is processed asynchronously relative to other related cells and is queued before being multiplexed over the transmission path.

Because ATM is designed to be easily implemented in hardware (rather than software), faster processing and port speeds are possible. The pre-specified bit rates are either 155.520 Mbps or 622.080 Mbps.

Gigabit Ethernet

Gigabit Ethernet, or GigE, a transmission technology based on the Ethernet frame format and protocol used in local area networks (LANs), provides a data rate of one billion bits per second (1000 Mbps). The Ethernet protocol is the most widely implemented network protocol today. Gigabit Ethernet has been standardized by the IEEE 802 Committee in 802.3z and 802.3ab.

Gigabit Ethernet is carried primarily on either single-mode or multi-mode optical fiber. Very short distances are possible using unshielded twisted pair (UTP) copper cable (such at CAT-5e or CAT-6 cable).

5.5.2 Network Technology Recommendation

Since the 1970's, telecommunications have been converging into an integrated digital network by digitizing all information, including voice and video. The traditional switching function in telecommunications networks has continued to evolve from manual (switchboards), spatial (step-by-step) or time division switching to packet switching. Several years ago, ATM was emerging as the universal switching technology. However, ATM was expensive. The Ethernet provided an alternate solution. The current rollout of digitizing voice communications and transporting them using internet protocol, (also called "voice over IP" or simply VoIP), replaces the traditional switch at a service provider's central office with a server and router that sends packets of data to their final destination.

Likewise, the transmission of video images is changing from analog to digital. High Definition Television (HDTV) represents a major upgrade to television broadcast industry and is being mandated by the Federal Communications Commission for future stations. This technology digitizes the analog video and compresses it for transmission. The resulting signal uses the available bandwidth more effectively and provides a better image to the user.

While the video surveillance systems for ITS and security applications are envisioned to continue to use the current National Television Systems Committee (NTSC) standards for the foreseeable future, the advances in digitization and compression make the digital transmission of video both practical and desirable.

The envisioned statewide network should use Gigabit Ethernet technology based on the following considerations:

- Gigabit Ethernet technology supports all known video and data requirements; it could be expanded to include voice communications.
- Gigabit Ethernet technology is less expensive that competing technology.
- A Gigabit Ethernet uses the same protocols as local area Ethernets. As such, it is simple to interface to legacy networks.
- Using IP, it is simple to transport data to and from the Internet. This provides the ability to use the Internet as a virtual private network (VPN).
- Gigabit Ethernets can use a variety of physical transmission media to connect users and for long-haul transmission.
- Since Gigabit Ethernets use equipment similar to equipment used in local digital networks, Information Technology (IT) personnel usually have the necessary experience and knowledge to administer and maintain the networks.
- The resilience and popularity of Ethernet technology demonstrates that any future transmission systems will need to address the backward compatibility of these components. This provides a degree of "future-proofing" the network against changes in technology.

5.5.3 Basic Network Model – Vision and Requirements

Network of Networks

The vision for a statewide ITS communication network consists of a network of smaller networks. Each district would be responsible for maintaining a local district network interconnecting local agencies and municipalities. A larger statewide network would provide robust inter-district communications. Defining the local district networks is outside the scope of this document.

District Connections

All district headquarters currently have a connection to the existing IDOT network. Current and future ITS data and video requirements may not require a network connection upgrade for some districts. Other districts, in order to meet these requirements, will require a new network connection.

New connections between IDOT district offices can be established by several methods including:

1) using existing IDOT owned infrastructure such as fiber optic cable
2) installing new IDOT owned infrastructure such as fiber optic cable
3) using existing non-IDOT owned infrastructure leased either through the ICN or through an ISP
4) some combination of the above

If IDOT-owned or IDOT accessible communications is within the vicinity, the district may choose to connect directly to the existing infrastructure. Access to the existing infrastructure may require the installation of additional conduit and fiber optic cable. If IDOT-owned infrastructure is not accessible to a district, the district may connect to the statewide communication network using the Illinois Century Network (ICN).

Overview of ICN connectivity
Connecting to the ICN requires connecting to the nearest ICN point-of-presence (POP). This can be established through one of two means:

1) Contract through a local Internet Service Provider (ISP) to provide connectivity
2) Install new communication infrastructure, such as fiber optic cable and conduit, between the district office and the ICN POP.

There must also exist a gateway between the ICN and the statewide communication network.

Public networks and use of VPN
If neither IDOT-owned nor accessible communication infrastructure or an ICN POP is in the vicinity, the district may connect to the communication network using a public network. The connection would traverse through the public Internet using an ISP and connect to the network through a gateway. Because the information would be traversing a public network where non-intended users may have access to sensitive information, a Virtual Private Network (VPN) would be used to encrypt and protection information.

Current Infrastructure Support
The primary re-use of the existing infrastructure will be in District 1. To build the communications backbone, maximum use should be made of the existing agreements with ISTHA and their fiber along I-355 and with District 1 to share their communications backbone.

To connect Districts 2, 4, and 8 to the backbone, fiber that has been installed to support district requirements will be used. This fiber will provide the necessary ingress to the operations centers.

5.6 Opportunities and Recommendations for Communication Deployments

5.6.1 Building the Backbone
This effort consists of installing fiber optic cable from existing fiber optic segments and installing networking equipment at key locations. Specific requirements include:

- Install fiber optic cable from existing Williams fiber into IDOT Central Office building in Springfield
- Install terminal equipment and communication equipment in Springfield
- Install fiber optic cable from northern end of the Williams cable to the ISTHA toll plaza at I-355 and Boughton Road.
- Install terminal equipment and router in the IDOT District 1 communications center and the ITS program office.
- Install fiber from I-55/I-255 Interchange and the Williams fiber to District 8 Traffic Operations Center

A vision of the Illinois statewide ITS communications network is shown in Figure 5-11.

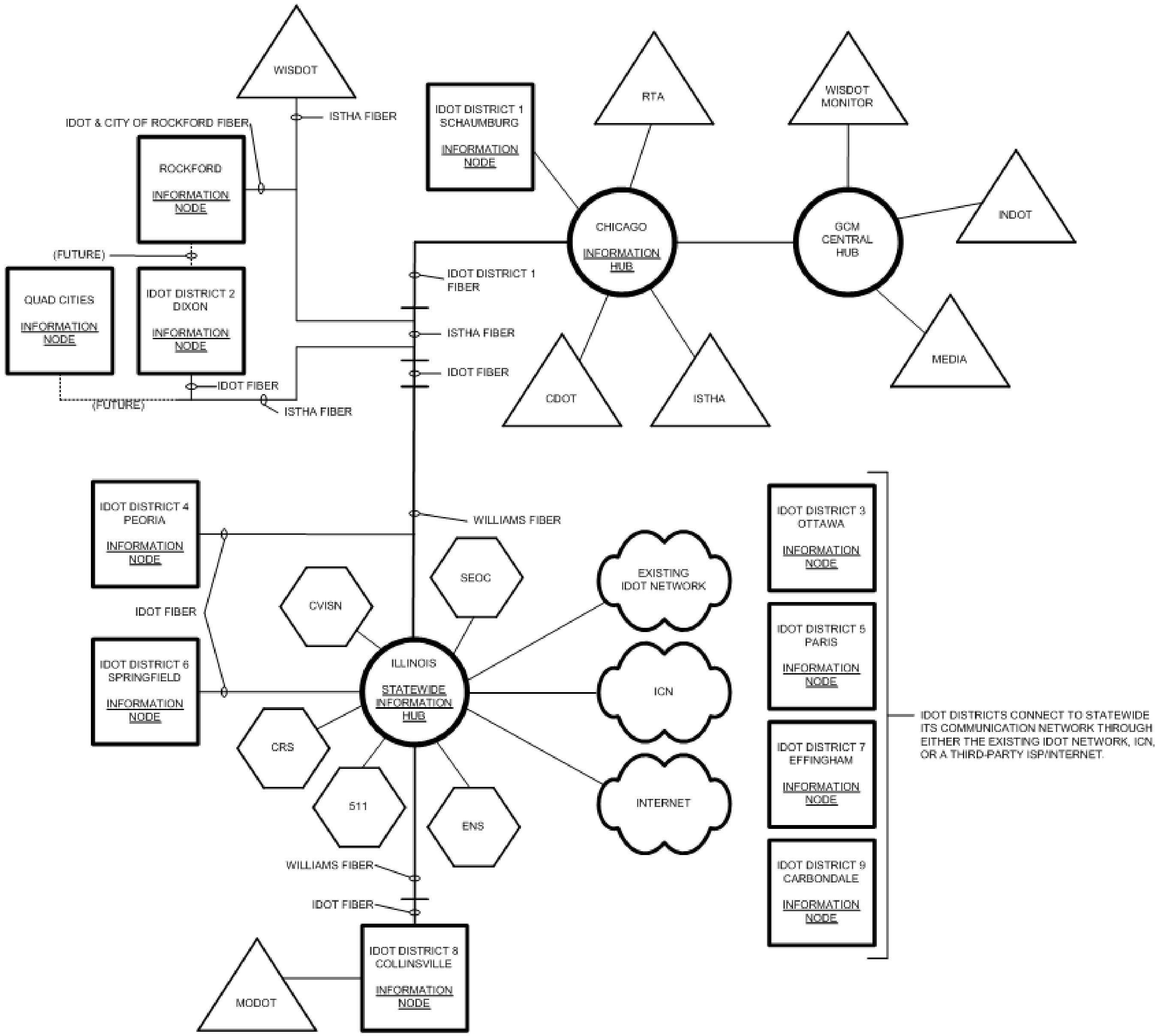

Figure 5-11 – Illinois Statewide ITS Communications Network

5.6.2 Making network connections

It is envisioned that the primary network users will connect to the network, as identified in the network models, using the methods identified in Table 5-6.

USER	CONNECTION METHOD	COMMENTS
IDOT District 1 Communication Center	Router on statewide network	Connects to Traffic System Center (TSC)
IDOT District 2	Router on statewide network	
IDOT District 3	Existing IDOT network, ICN, or leased ISP/Internet	
IDOT District 4 Communication Center	Router on statewide network	
IDOT District 5	Existing IDOT network, ICN, or leased ISP/Internet	
IDOT District 6	Router on statewide network	
IDOT District 7	Existing IDOT network, ICN, or leased ISP/Internet	
IDOT District 8 Traffic Operations Center	Router on statewide network	
IDOT District 9	Existing IDOT network, ICN, or leased ISP/Internet	
Illinois Gateway	Router on statewide network	
Illinois EOC	Router on statewide network	
ISTHA TIMS	Gigabit Ethernet Node	Routed through IDOT District 1 WAN
CDOT EOMC	Gigabit Ethernet Node	Routed through IDOT District 1 WAN

Table 5-6 – IDOT District and Agency Connection to the Illinois Statewide Network